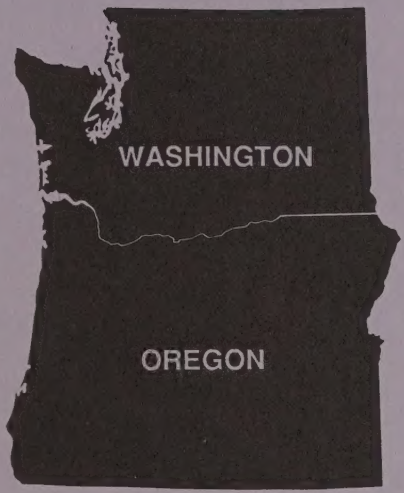
United States
Department of
Agriculture

Forest Service

**Pacific
Northwest
Region**

Forest Pest Management



1992 UMATILLA AND WALLOWA-WHITMAN NATIONAL FORESTS WESTERN SPRUCE BUDWORM SUPPRESSION PROJECT

Striving for a healthy forest.

1992 UMATILLA AND WALLOWA-WHITMAN NATIONAL FORESTS

WESTERN SPRUCE BUDWORM SUPPRESSION PROJECT

LA GRANDE AND WALLA WALLA RANGER DISRICTS

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INCIDENT COMMANDER
USDA FOREST SERVICE - FOREST PEST MANAGEMENT
PORTLAND, OREGON

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1992 UMATILLA AND WALLOWA-WHITMAN NATIONAL FORESTS WESTERN SPRUCE BUDWORM SUPPRESSION PROJECT

LA GRANDE AND WALLA WALLA RANGER DISTRICTS

INTRODUCTION

Western spruce budworm (*Choristoneura occidentalis* Freeman) populations have been at outbreak levels on portions of the Umatilla and Wallowa-Whitman National Forests in northeast Oregon since the early 1980's. Defoliation caused by the budworm outbreaks, in combination with impacts from several other pests, severe drought, and other stress factors, has resulted in serious forest health decline over hundreds of thousands of acres of forests in the Blue Mountains of northeast Oregon and southeast Washington.

In 1990 and 1991, both National Forests established budworm analysis units to estimate budworm population levels, and assess the effects of the outbreaks and management alternatives on resource management. Biological evaluation of the budworm infestations in the analysis units done in the summer of 1991 predicted that population densities in 1992 would be high enough to cause moderate to severe defoliation (Scott, D.W., 1991 Biological evaluation of western spruce budworm in 1992 analysis units on the Umatilla and Wallowa-Whitman National Forests. Rep. BMZ-91-04, USDA-Forest Service, Wallowa-Whitman NF. La Grande, OR. 54 p.)

The two National Forests prepared a site-specific Environmental Assessment, "Umatilla and Wallowa-Whitman National Forests Western Spruce Budworm". The alternative selected in the EA was to suppress the budworm population on 185,373 acres in seven analysis units with the biological insecticide *Bacillus thuringiensis* variety *kurstaki* (Btk). A Decision Notice and Finding of No Significant Impact was signed by Forest Supervisors from both National Forests by December 3, 1991.

A decision was made to split the areas to be sprayed into two separately administered projects because of the distance separating the treatment areas. The La Grande project included the analysis units on the La Grande and Walla Walla Districts, the Enterprise project included analysis units on the Wallowa Valley District. This report describes the objective, location, organization, procedures, and results of the La Grande project. A separate report describes the Enterprise project.

OBJECTIVE

The objective of the suppression project was to safely, efficiently, and economically reduce the western spruce budworm populations within the treatment areas to levels that would not cause additional, unacceptable resource damage for several years. The suppression target goal for each analysis unit was to reduce the budworm population by 90 percent, unadjusted for natural mortality, in the time period from the prespray sampling to the postspray sampling.

PROJECT AREA

The suppression project was done in stands with large proportions of western spruce budworm host species on the La Grande and Walla Walla Districts. The project was separated into five analysis units for purposes of entomology sampling and analysis. The general vicinity map (Figure 1) shows the location of the analysis units. The following paragraphs describe the general location and characteristics of the analysis units:

- Mill: This analysis unit on the Walla Walla District is located approximately 15 miles southeast of Dayton, Washington. A total of 5,960 National Forest treatment acres was in this unit. Ski Bluewood, a commercial ski operation, is located within the treatment unit. More than 90 percent of the trees per acre in the treatment area are budworm host species.

- Thimbleberry: The unit is located approximately 15-20 miles northwest of Elgin, Oregon. It had 32,902 treatment acres of National Forest and 823 treatment acres of non-federal lands. About 88 percent of the trees per acre are budworm host species.

- Meacham-Trail: The analysis unit is located approximately 10 miles northwest of La Grande, Oregon, along Interstate 84N. There are 28,954 treatment acres, of which 22,335 are on National Forest. Eight non-federal landowners have stands that were sprayed. Nearly 70 percent of the trees per acre are budworm host species. The Oregon Trail passes through the treatment unit.

- Mt Emily: The unit is located about 5 miles north of La Grande, Oregon. There are 25,386 treatment acres, of which 24,804 are National Forest. Over 90 percent of the trees per acre are budworm host species.

- Indian Creek: The analysis unit is located approximately 10 miles southeast of Elgin, Oregon and 3 miles north and east of Cove, Oregon. There are 20,248 treatment acres, of which 18,818 are National Forest. Six non-federal landowners have parcels of stands that were sprayed. About 85 percent of the trees per acre are budworm host species.

Terrain in the project area is highly varied, ranging from large, relatively flat plateaus to very steep slopes, and narrow canyons. Elevation extends from approximately 2,800 to 7,000 feet above sea level.

The treatment units were divided into 209 spray blocks, based on topography and elevation.

PROJECT ORGANIZATION

An Incident Command System organization, modified to fit the needs of a forest defoliator suppression project, was used to manage the project. The organization is displayed in Figure 2. A total of 63 Forest Service, Oregon Department of Forestry, and Bureau of Land management personnel worked on-site on the project. Resource orders for all personnel were issued by the Wallowa-Whitman National Forest Dispatch Office. The contractor had about 40 employees on site.

CONTRACTING

Heli-Jet Corporation, from Eugene, Oregon was the contractor.

The Forest Service used a Request For Proposals (RFP) to solicit, negotiate, and award the contract. Items contracted for were application aircraft and support equipment and personnel, sufficient Btk insecticide to spray 116,000 acres, marking of project block boundaries, application of insecticide, and observation helicopters and pilots certified to transport government employees.

The Forest Service specified that any of three commercially available Btk products could be used on the project. The three products were Thuricide 48 LV, Foray 48B, and Dipel 6AF. All application was to be at the rate of 1/2 gallon of undiluted insecticide per acre. This equated to 24 BIU per acre of active ingredient.

Three aerial applicators responded to the RFP with technical and price proposals. Heli-Jet was awarded the contract for the project on the basis of the strenght of the technical approach and price. The contract was awarded at the price of $13.35 per acre. This was subsequently renegotiated to $13.84 per acre after the Forest Service requested the contractor increase their hourly production capability by adding two application helicopters and one observation helicopter.

Heli-Jet agreed to provide 2 Turbo Thrush airplanes, 4 Hiller Soloys, and 2 Bell 205s for application. They added one Bell 205 and a Bell 212 after spraying began, to be able to keep pace with the acres being released for spraying. The observation helicopter fleet consisted of 6 Bell 206 BIII Jet Rangers.

Heli-Jet sprayed Thuricide 48 LV, supplied by Sandoz Crop Protection Corporation.

FACILITIES AND EQUIPMENT

The Forest Service set up an administrative office and technical center at the La Grande Fire Center at the La Grande and Union County airport.

A large quantity of supplies and equipment needed for the project was resource ordered from the Forest Pest Management suppression cache and the National Fire Equipment System cache at the La Grande Fire Cache and the Redmond Air Center. Several incidental supplies were purchased locally. A radio system was ordered from the Boise Inter-Agency Fire Center. It was installed and maintained by Umatilla National Forest radio technicians.

Heli-Jet established staging areas at the La Grande airport, Pendleton Ranch property in Meacham, Oregon, Fox Prairie, and the Ski Bluewood parking lot.

SPRAY OPERATIONS

Spray blocks were designated by the Forest Service as helicopter treatment only or treatment allowed by either helicopter or single engine, fixed wing aircraft. The basis for aircraft assignment was safety, and size and shape of blocks. Heli-Jet was responsible for assigning specific aircraft to the spray blocks.

Spray blocks were marked for spraying by placing bright orange, yellow-green, and white streamers in snags and tall trees along the boundaries. This was done by contractor personnel tossing markers from helicopters. Ground panels and distinctive ground features were used as aids in marking blocks. Heli-Jet also used large white retrievable hoops to mark some blocks to be sprayed by the airplanes. The hoops were more visible to the pilots than the streamers.

Spray aircraft were calibrated and characterized at four separate locations. A SwathKit was used to measure and analyze the spray patterns created during the characterization spray runs. The Hiller Soloys were calibrated for a swath width of 90 feet and a flow rate of 5.5 gallons per minute with the application speed of 60 MPH. Volume Median Diameter for spray drop patterns from the Soloys ranged between 132 and 241 microns for the four aircraft. All the Hiller Soloys were fitted with six Beecomist 360 atomizers. The Bell 205s and Bell 212 were calibrated for a swath width of 130 feet and a flow rate of 13.1 gallons per minute at the application speed of 92 MPH. Analysis of the characterization runs showed that all of these aircraft could produce a swath width of 140 feet. Volume Median Diameter for spray drop patterns from the four 205s and 212 ranged from 167 to 257 microns. All four of the helicopters were fitted with 8 Beecomist 360 atomizers. All were positioned at the same locations on the booms and all had the same size restrictor plates. The two Thrushes were calibrated for a swath width of 140 feet and a flow rate of 18.1 gallons per minute at an application speed of 135 MPH. Volume Median Diameter for spray drop patterns from the Thrushes ranged from 106 to 110 microns. The Thrushes were each fitted with 8 Micronair AU 5000 atomizers. All application aircraft were equipped with Crophawk flow meters.

Thuricide 48LV was delivered to the contractor in bulk truck tanker shipments. No dye was added to the insecticide, except for the characterization inspections. Insecticide was metered by the contractor and monitored by the Forest Service when it was pumped from storage tanks or batch trucks into the application aircraft. The contractor was paid on the basis of gallons of insecticide pumped into the aircraft and then applied as called for in contract specifications.

Application and observation pilots and Forest Service aerial inspectors flew over the spray blocks prior to their scheduled treatment to familiarize themselves with block features and determine spray tactics.

The application aircraft flew in teams of two or solo, accompanied by a single observation helicopter. Spraying was allowed only when observation helicopters were present. Spray and observation aircraft, ground equipment, and personnel were formed into teams that operated together throughout most of the project. The spray airplanes flew from the La Grande airport and Meacham airstrip. The spray helicopters operated out of temporary helispots located throughout the project area.

The following criteria had to be met before spraying could proceed: wind speed between 1 and 8 MPH, relative humidity greater than 55%, temperature between 33 and 70 degrees, no drops of water on the foliage, and no rain predicted to fall within 6 hours of spraying.

Ground-based observers monitored weather in the spray blocks the morning they were scheduled for spraying. Wind speed, wind direction, temperature, and relative humidity were measured and radioed to the aircraft staging sites. In addition, weather conditions were monitored from 3 Remote Area Weather Stations in or close to the project area. Spot forecasts were obtained from the National Weather Service Office in Pendleton, Oregon.

Ground observers placed white Kromekote cards in lines in some spray blocks to monitor spray deposit. Cards were placed at least one full tree height away from trees, where possible. The number of cards per line varied from 3 to 10. All cards were placed on the ground in plastic holders. Spray drops seen within two 1 square centimeter fields predrawn on the cards were counted by the ground observers using dissecting microscopes.

Spray blocks were to be sprayed within 72 hours of being released or they would be temporarily withdrawn until another prespray budworm larval sample was taken. In the course of the project several spray blocks were prespray sampled more than once.

A daily shift plan developed by the Forest Service and the contractor documented the aircraft, personnel, and radio channels to be used by each spray team to accomplish spraying the released blocks. Treatment priorities were assigned to spray blocks. A daily safety message was attached to the shift plan.

Pilots and aerial observers reviewed their assignments each morning prior to begining spraying. All aircraft reported their locations to the project dispatcher or staging area managers every 15 minutes when flying.

ENTOMOLOGY OPERATIONS

The entomology section consisted of two entomologists, two experienced assistants, and four technicians. The Mill analysis unit was handled from Walla Walla by one entomologist (through block release) and up to four assistants from the Walla Walla District. All individuals worked the field alone.

The tasks of the entomology operations were to determine when the spray blocks should be released for spraying to optimize treatment effectiveness, and to sample and estimate the budworm population before and after spraying.

A minimum of 30 budworm density sampling plots were established within each analysis unit. These plots were accessible from roads but far enough away to avoid excessive exposure to dust. Every spray block did not have a sampling plot, some had more than one. The plots were distributed throughout the analysis units. A plot contained five open grown Douglas-firs or true firs, 20 to 50 feet tall. Only one tree species was represented in each plot. The same trees were used for both prespray and postspray sampling.

The two Districts requested that some areas be sprayed twice to provide extra protection to important visual resources. One of the areas was located in the Meacham analysis unit at the site being developed for the Oregon Trails Intrepretive Wayside. Fifteen budworm density sampling plots were established in the double spray area. This was the only area sprayed twice.

Larval and tree development were monitored to determine when individual spray blocks met release criteria. Blocks were released for spraying when the first sixth instar larva was seen and at least 95 percent of all new shoots had unfurled (i.e., the budcap was gone and the new shoots elongated so the needles were no longer bunched). In most cases, sixth instar larvae were found before 95 percent of the new growth had unfurled, so the blocks were not released until shoot development progressed. Development monitoring involved assessing larvae sampled in lower crowns and shoots by visual estimate within each accessible spray block. Monitoring was prioritized by looking at low elevations, southern exposures first and high elevations, northern exposures last. Those blocks with no road access were released for spraying when adjacent blocks with the same elevation and aspect met release criteria and a visual survey from a helicopter by the project entomologist confirmed foliage readiness.

Different spray block release criteria were used for the portion of the Meacham analysis unit sprayed twice than were used for the blocks sprayed once. Blocks were released for the first spray by the project entomologist 5 to 10 days in advance of when he felt at least 95 percent of the shoots would be unfurled and the first sixth instar would be seen. They were released for the second spray when they met the criteria used to release blocks to be sprayed once.

Budworm density sampling plots in released spray blocks were sampled within 24 hours of release, using lower crown sampling procedures. Three, approximately 18 inch long branch tips from each of the five plot trees were beaten over a standard beating cloth/frame, then they were cut and discarded to prevent their being sampled again. All budworms on the cloth were counted and the instar of each determined. If a block was not sprayed within 72 hours of this sample the plot was resampled.

The postspray budworm density sample was taken in each evaluation plot when the first pupa was observed, but no sooner than 14 days and no later than 21 days after the block had been sprayed. The sampling procedure was the same as that used for the prespray sampling.

All lower crown population sample data were converted to mid-crown branch tip equivalents using the equation $Y = .3513 + .6781X$ where Y = mid-crown branch tip budworm density and X = budworm density of the 3 branch lower crown sample (Torgersen,T.R., D.W. Scott, T.F. Gregg, and K.P. Hosman [In Preparation] Sampling western spruce budworm, *Choristoneura occidentalis* Freeman [Lepidoptera: Tortricidae] by lower-crown beating after treatment with *Bacillus thuringiensis* Berliner).

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SPRAY OPERATIONS ACCOMPLISHMENTS

Analysis unit treatment data are displayed in Table 1 (Appendix). A total of 116,344 acres was sprayed. Approximately 500 acres scheduled to be sprayed in the Indian Creek analysis unit were not sprayed because of insufficient insecticide. Insecticide application began on May 30 and was completed on June 18. Four days were not suitable for spraying because of rain and fog. Low relative humidity limited the time available for spraying several mornings.

The two Thrushes sprayed 32,816 acres. They averaged 514 acres per hour per aircraft. The four Hiller Soloys sprayed 31,564 acres and averaged 311 acres per hour per aircraft. The three Bell 205s sprayed 41,892 acres and averaged 619 acres per hour. The Bell 212 sprayed 10,072 acres, averaging 907 acres per hour.

A total of 521.7 flight hours were flown on the project.

Seventy four card lines, with a total of 647 spray cards, were placed in 66 spray blocks. Spray drops were seen on 92 percent of the cards and drop density averaged 15 drops per square centimeter. The percentage of cards with measured spray was slightly higher in spray blocks sprayed by airplanes than those sprayed by helicopters. The average spray drop density was greatest on cards in the airplane sprayed blocks.

No handling problems were experienced with the insecticide.

ENTOMOLOGY SAMPLING RESULTS

A total of 165 5-tree budworm density plots were established for prespray and postspray sampling. Not all these plots were used for sampling. Some were dropped if the areas they were in were excluded from spraying.

Population sampling results are displayed for the analysis units in Tables 2 and 3 (appendix) and Figure 3. Population reductions, unadjusted for natural mortality, based on mid-crown branch tip densities, did not reach 90 percent in any of the analysis units. Graphic displays of prespray and postspray population densities from the lower crown branch sampling for each analysis unit are shown in Figures 4 to 9. All project entomology data are on file at the Forest Pest Management office in Portland, Oregon.

The first spray block (Indian Creek H-0) was released on May 29 for spraying on May 30. On the same date, portions of Meacham blocks MF-1, MF-2, MH-1, and MH-2 selected for double treatment were released to receive the first spray application. By May 31, 21 blocks had been released, with indications of large numbers of blocks meeting release criteria over the next few days. From June 1 to 3, an additional 107 spray blocks were released. The remaining blocks were released between June 4 and June 8.

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[illegible] problems were experienced with the insecticide.

ENTOMOLOGY SAMPLING [illegible]

[illegible] budworm density plots were established [illegible] prespray and postspray sampling were used for sampling. Some were dropped [illegible] they were in [illegible]

[illegible] results are displayed for the analysis units in Tables 7 and 8 (Appendix) and [illegible] population reductions, unadjusted for natural mortality, based on mid-crown branch [illegible] [illegible] reach [illegible] percent in any of the analysis units. Graphic display of prespray and [illegible] population densities from the lower crown branch sampling for each analysis unit [illegible] [illegible] 4 to 9. All project entomology data are on file in the Forest Pest Management [illegible] Oregon.

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BUDGET

Cost of the project was $1,964,028. Cost per sprayed acre averaged $16.88. A breakdown of costs is shown in Table 4. The contract accounted for $13.84 per acre, with administrative costs being $3.04 per acre. All costs of spraying National Forests were paid by the Federal government. Cost of spraying 11,454 acres of non-federal lands were shared with the owners. Individuals or businesses owning less than 500 acres sprayed paid 50 percent of the cost. Those with more than 500 acres paid 66 percent of the cost. State agencies paid 75 percent of the cost of spraying lands they owned.

SAFETY

There were no reported accidents, injuries, or spills on the project. Driving on dusty roads in the dark was one of the most hazardous activities on the project. Approximately 50,000 miles were driven by project personnel.

DISCUSSION

The short term goal of achieving a 90 percent population reduction, unadjusted for natural mortality, was not met on any of the five analysis units using the converted mid-crown branch budworm densities as the comparison unit. The populations declined by a low of 79 percent on the Thimbleberry analysis unit to a high of 87 percent on Indian Creek. The population reduction measured is a result of a combination of insecticidal effects and natural mortality. No attempts were made to quantify the contributions of various mortality components.

The postspray population density is a better indication of short-term project success than percent population decline. Recent western spruce budworm suppression projects done by the Forest Service in Oregon and Washington have had a goal of reducing the budworm population to 1 or less larva and/or pupa per 18 inch midcrown branch in the postspray analysis unit samples. This target was not used for this project. None of the 5 analysis units had a postspray budworm density of 1 or less, although Indian Creek was close with 1.1. The Mill unit, with a postspray density of 3.4 probably has the greatest potential for the fastest budworm population resurgence for all the sprayed units.

Postspray density measured in the double sprayed area in the Meacham unit was higher than three analysis units that received a single insecticide application. The budworm population sampled declined by 77 percent from the first prespray sample to the postspray sample. Defoliation intensity in the double spray area was compared to that seen in adjacent single spray areas during aerial surveys in August by an experienced aerial observer. There were no obvious differences in the intensity of defoliation between the double sprayed and single sprayed areas. A July hail and rain storm that covered large areas of northeast Oregon and southeast Washington knocked off much of the dried, shrivelled red foliage, reducing the reddish brown appearance caused by budworm feeding. It appears that double spraying did not achieve the intent of extra foliage protection.

Although the short-term goal of reducing the budworm population by 90 percent was not met in any of the analysis units, I believe that the populations in the sprayed areas have declined to levels where defoliation will be reduced for the next 1 to 3 years from intensities seen in 1991. This, in turn, may provide some degree of short-term recovery for the defoliated trees. Unless actions are taken to reduce the susceptibility of the stands to budworm outbreaks, such as reducing the proportion of budworm host species, there is a high liklihood the sprayed areas will be subject to budworm outbreaks within just a few years.

The reasons for not achieving greater budworm population declines in the sprayed areas are unknown. Data were examined to determine if factors such as tree species, type of application aircraft, and spray time in relation to time before measureable rainfall could be contributing factors. Although statistical analyses were not done, none of these factors appeared to be associated with higher than desired postspray densities.

I suspect that one likely explanation for the variable population decline is nonuniform deposition of insecticide in the analysis units. There may have been numerous instances of skips and oversprays. Some of the plot trees may not have received sufficient insecticide deposition to contribute to large population declines. Skips are an unfortunate, but not uncommon occurrence, on many large forest spray projects where precise navigation can be difficult due to terrain and lack of distinctive sighting features. Spray deposition cards were not placed in the budworm density sample plots, so it is not known how much, if any, insecticide was deposited on the sample trees. Although spray deposition on card lines in the spray blocks appeared to be very good there is no assurance similar deposition occurred on all of the plot trees.

Western spruce budworm populations were sampled in several locations close to the project area as part of a process analyzing the need for potential suppression in 1993. This sampling detected a decrease in the budworm population compared to the data collected in the same general areas in 1991. The reasons for the decline in the populations are unknown.

The organization and approach used to manage the project was effective. Administrative costs were lower than those experienced on most recent defoliator suppression projects. The negotiated contract process resulted in obtaining the services of a firm with several years experience spraying Pacific Northwest forests with high quality equipment. The safety record of the project, which had a high potential for accidents, was excellent.

APPENDIX

Table 1. 1992 Walla Walla and La Grande Districts western spruce budworm suppression project analysis unit treatment information.

Analysis Unit	Number Spray Blocks	Acres Sprayed
Indian Creek	28	19,748
Meacham Single spray	36	28,954
Meacham Double spray	4*	2,571
Mill	19	5,960
Mt. Emily	46	25,386
Thimbleberry	76	33,725
Total	209	116,344

* Portions of 4 spray blocks in the Meacham analysis unit were sprayed twice.

Table 2. 1992 western spruce budworm population densities for the La Grande and Walla Walla District analysis units.

		*Budworm Density (mean + SE)**	
Analysis Unit	**No. Plots**	**Budworms per 3-branch Lower crown sample**	**Budworms per 18-inch Mid-crown Branchtip****
PRESPRAY			
Indian Creek	30	11.5 + 1.0	8.2
Meacham	29	17.4 + 1.6	12.1
Mill	30	26.9 + 2.5	18.6
Mt. Emily	31	15.3 + 1.7	10.7
Thimbleberry	30	18.4 + 1.3	12.8
POSTSPRAY			
Indian Creek	27	1.0 + 0.3 (91)***	1.1 (87)
Meacham	29	2.5 + 0.4 (86)	2.1 (83)
Mill	30	4.5 + 0.8 (83)	3.4 (82)
Mt. Emily	31	2.3 + 0.4 (85)	1.9 (82)
Thimbleberry	30	3.5 + 0.7 (81)	2.7 (79)

* Standard Errors (SE) could not be reported for converted midcrown means.

** Budworms per 18 inch mid-crown branch tip converted from lower crown sample using the equation $Y = .3513 + .6781X$. (Torgersen et.al. In Preparation)

*** Numbers in the parenthesis are percent population declines estimated from prespray sampling to postspray sampling.

Table 3. 1992 western spruce budworm densities for the Meacham double spray block.

			Budworm density (mean + SE)*	
Sample Type	**Date Sampled**	**No. Plots**	**BW per 3-branch Lower Crown**	**BW per 18-inch Mid-crown Branchtip****
1st Prespray	5/29	15	16.5 + 2.1	11.5
2nd Prespray	6/5	15	11.2 + 1.0	7.9
Postspray	6/21	15	3.3 + 0.7 (80)***	2.6 (77)

* Standard Errors (SE) could not be reported for converted mid-crown means.

** Budworms per 18 inch mid-crown branch tip converted from lower crown sample using the equation $Y = .3513 + .6781X$. (Torgersen et.al. In Preparation).

*** Numbers in the parenthesis are percent population decline estimated from the first prespray sampling to the postspray sampling.

Table 4. Budget for the 1992 Walla Walla and La Grande Districts western spruce budworm suppression project.

Salaries and Per Diem	$267,714
Application contract	$1,610,698
Vehicles	$34,923
Supplies and equipment	$12,493
Forest overhead	$37,200
Total	$1,964,028

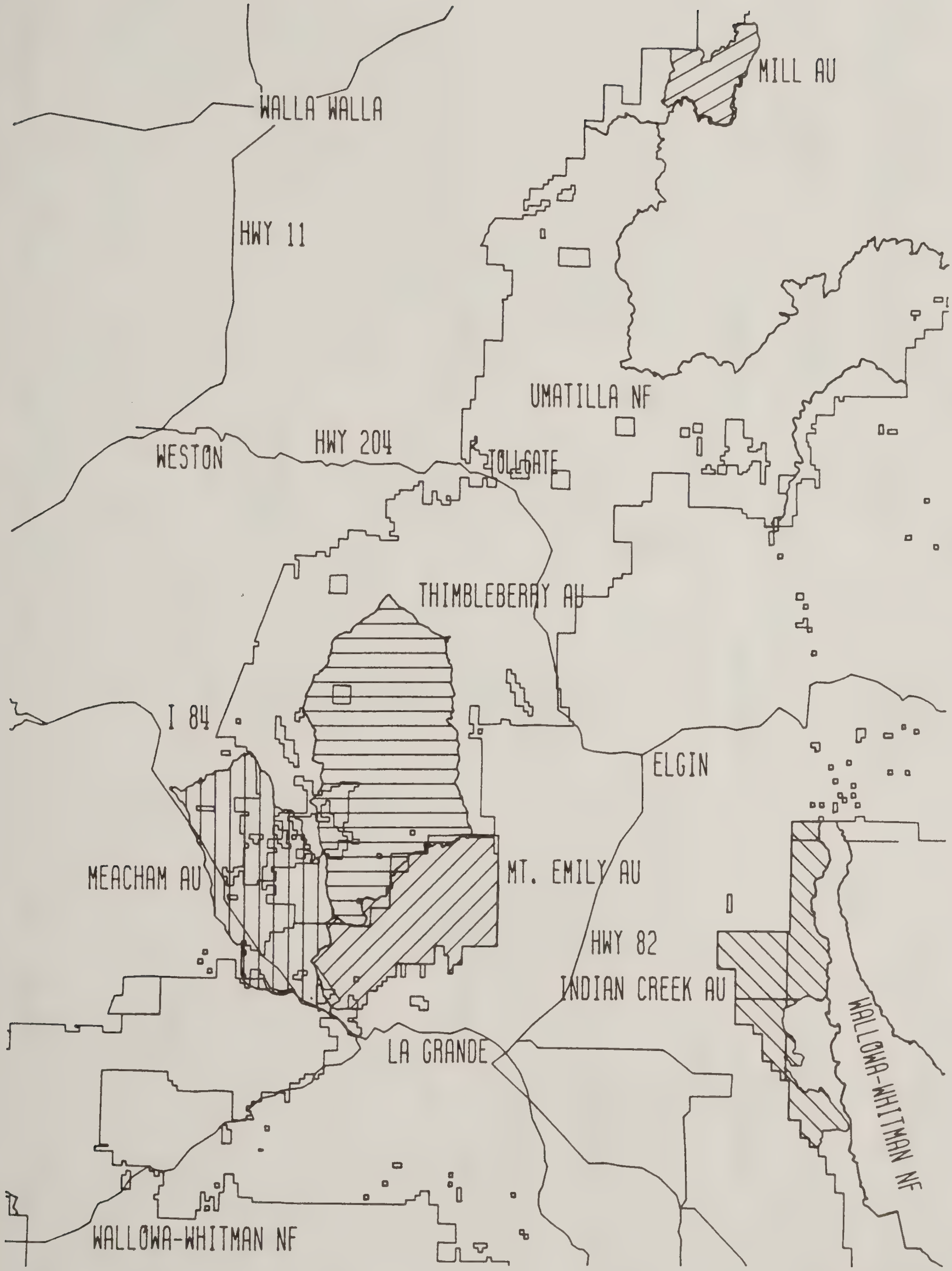


Figure 1. 1992 La Grande and Walla Walla Districts western spruce budworm suppression project analysis unit locations.

Figure 2. 1992 La Grande and Walla Walla District Western Spruce Budworm Project Organization

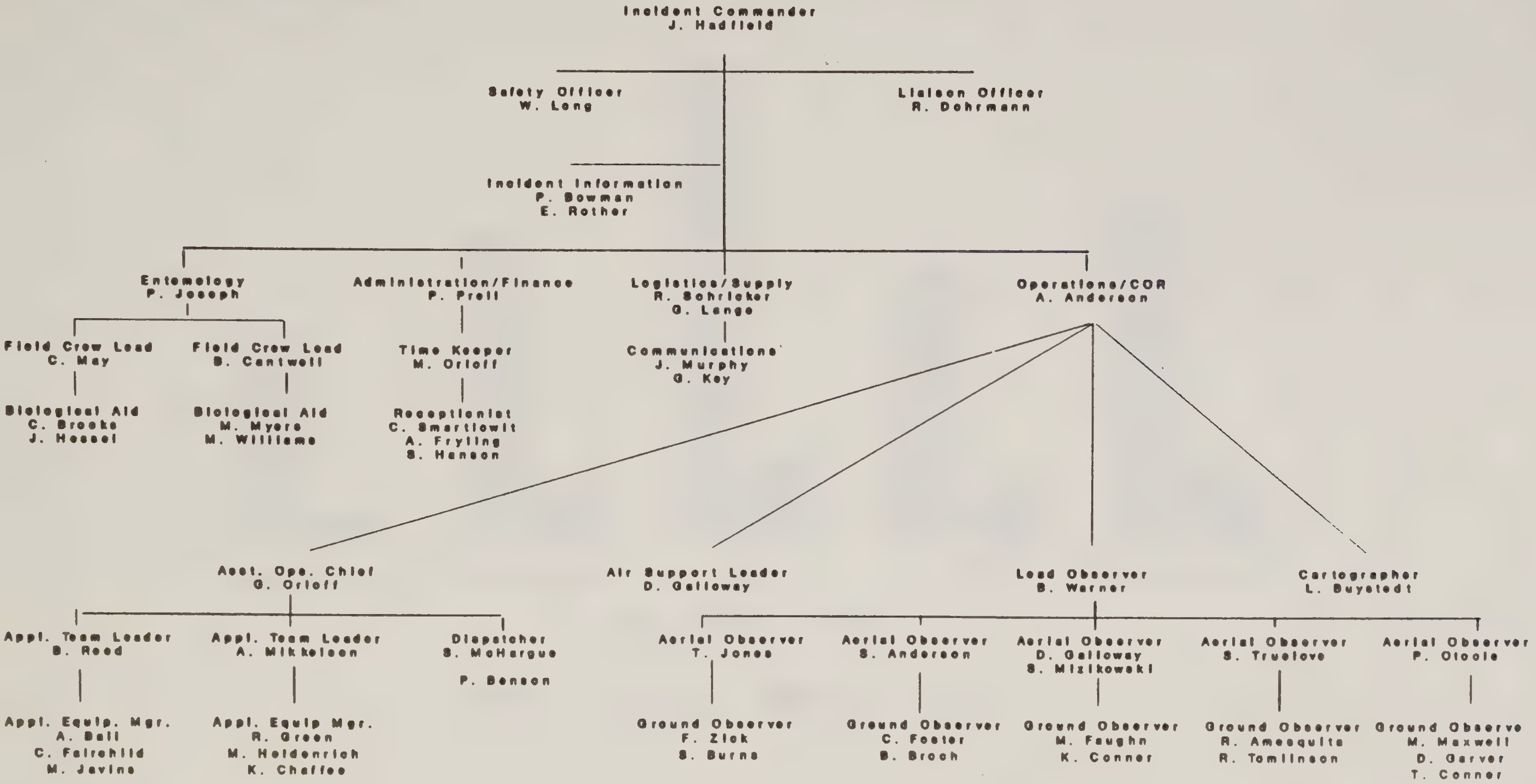


Figure 3. Projected western spruce budworm mid-crown branch densities for the 1992 La Grande and Walla Walla district analysis units.

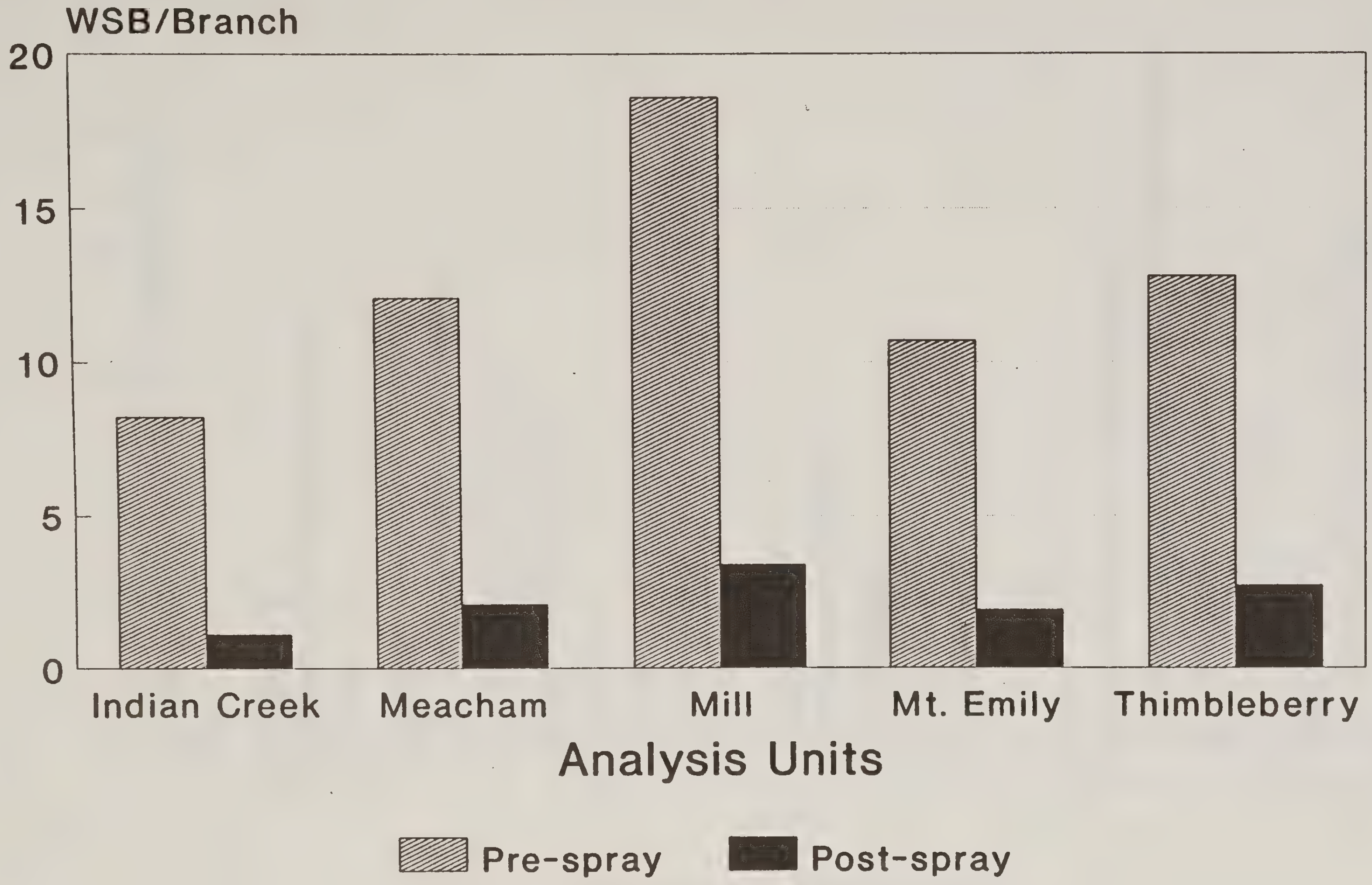


Figure 4. Western spruce budworm plot densities from lower crown branch samples in the Indian Creek analysis unit

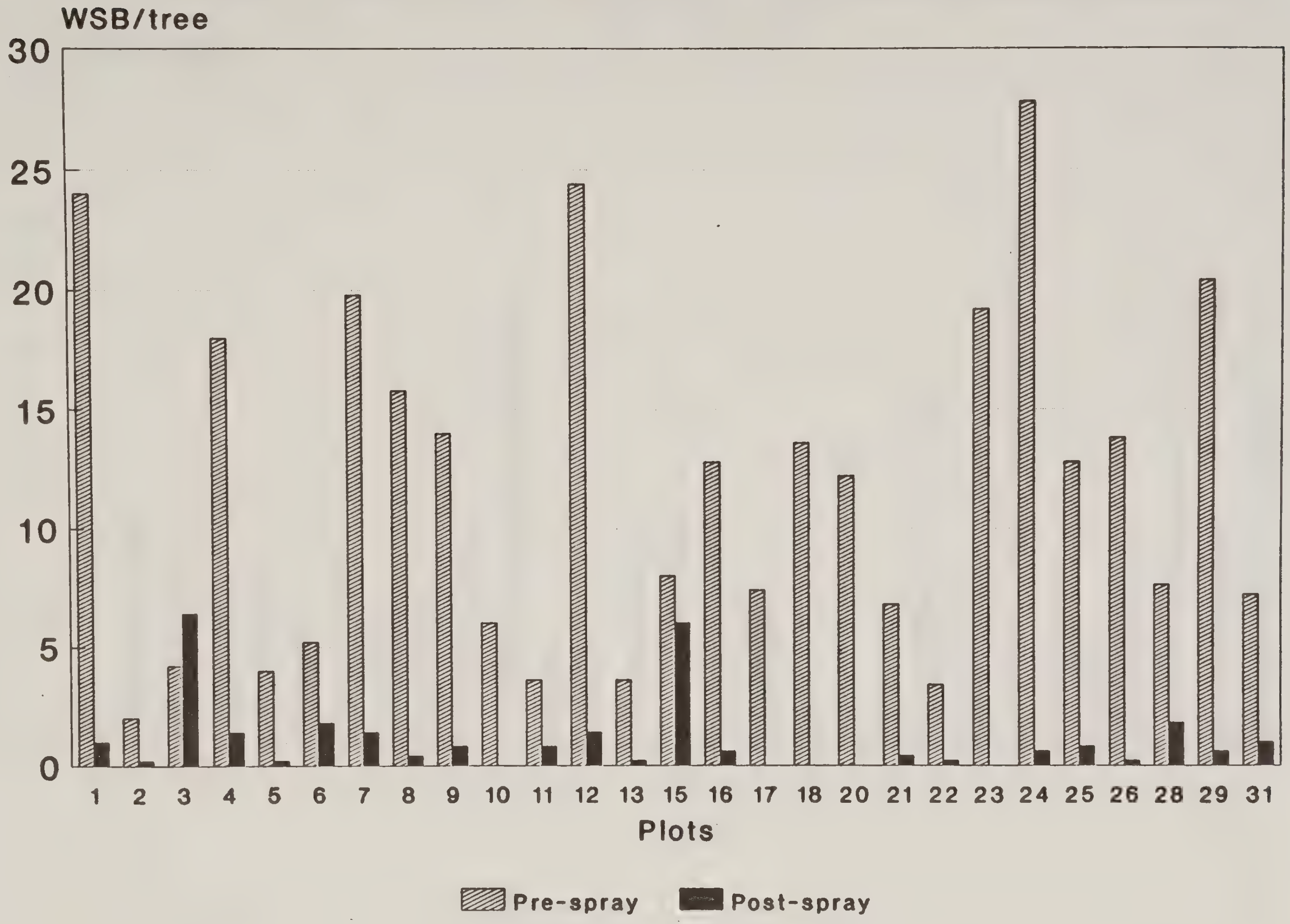


Figure 5. Western spruce budworm plot densities from lower crown branch samples in the Meacham single spray analysis unit.

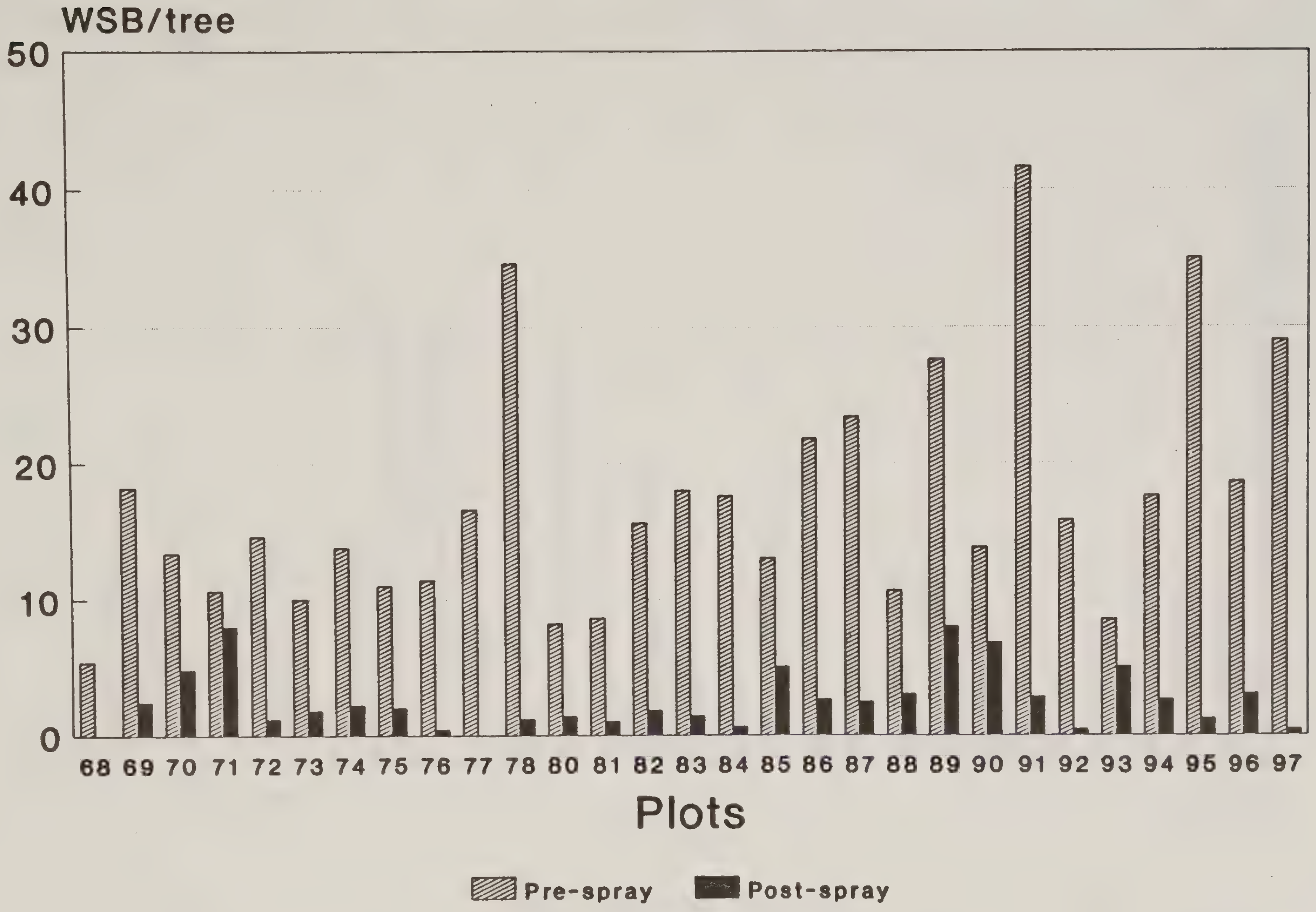


Figure 6. Western spruce budworm plot densities from lower crown branch samples in the Mill analysis unit.

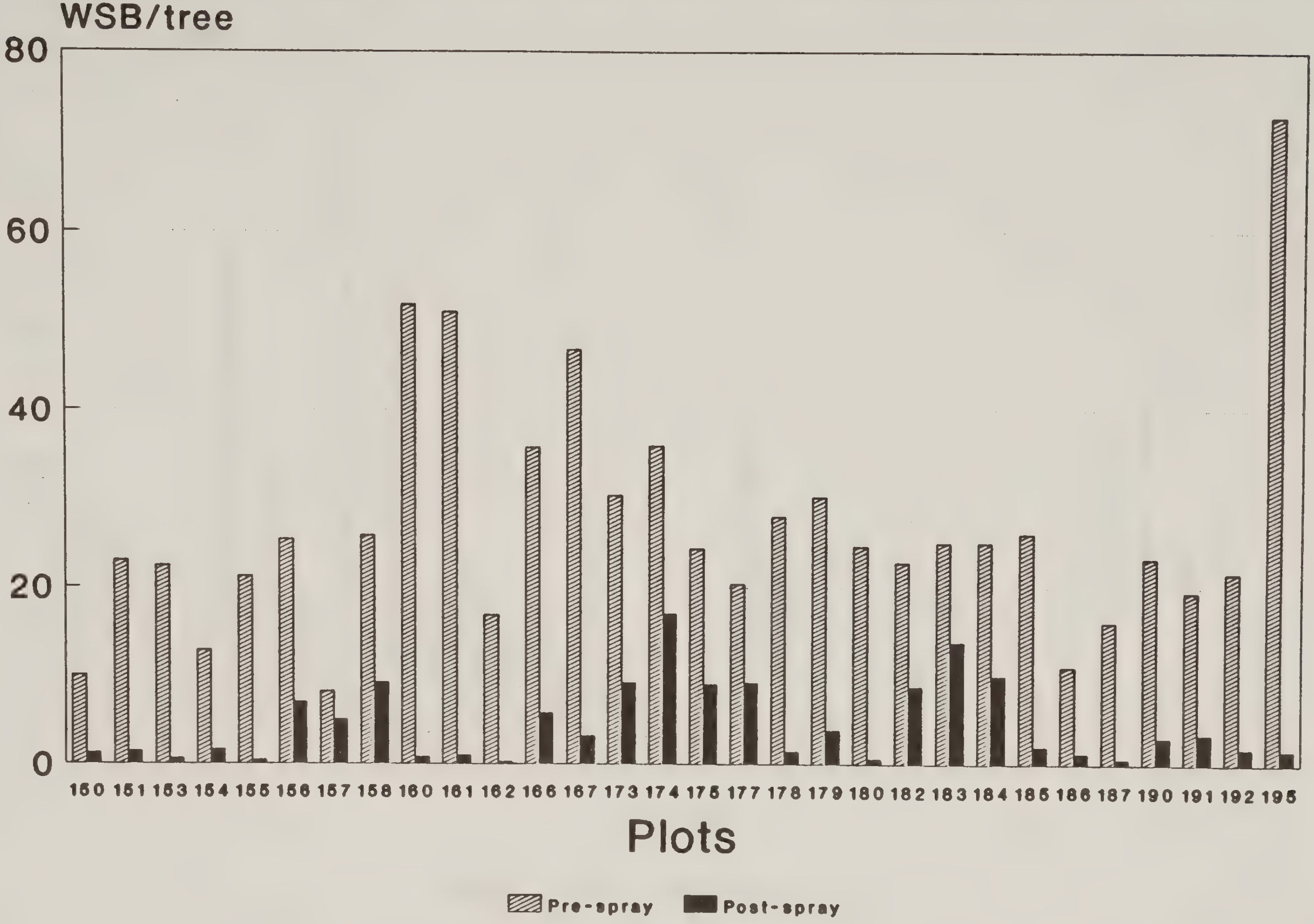
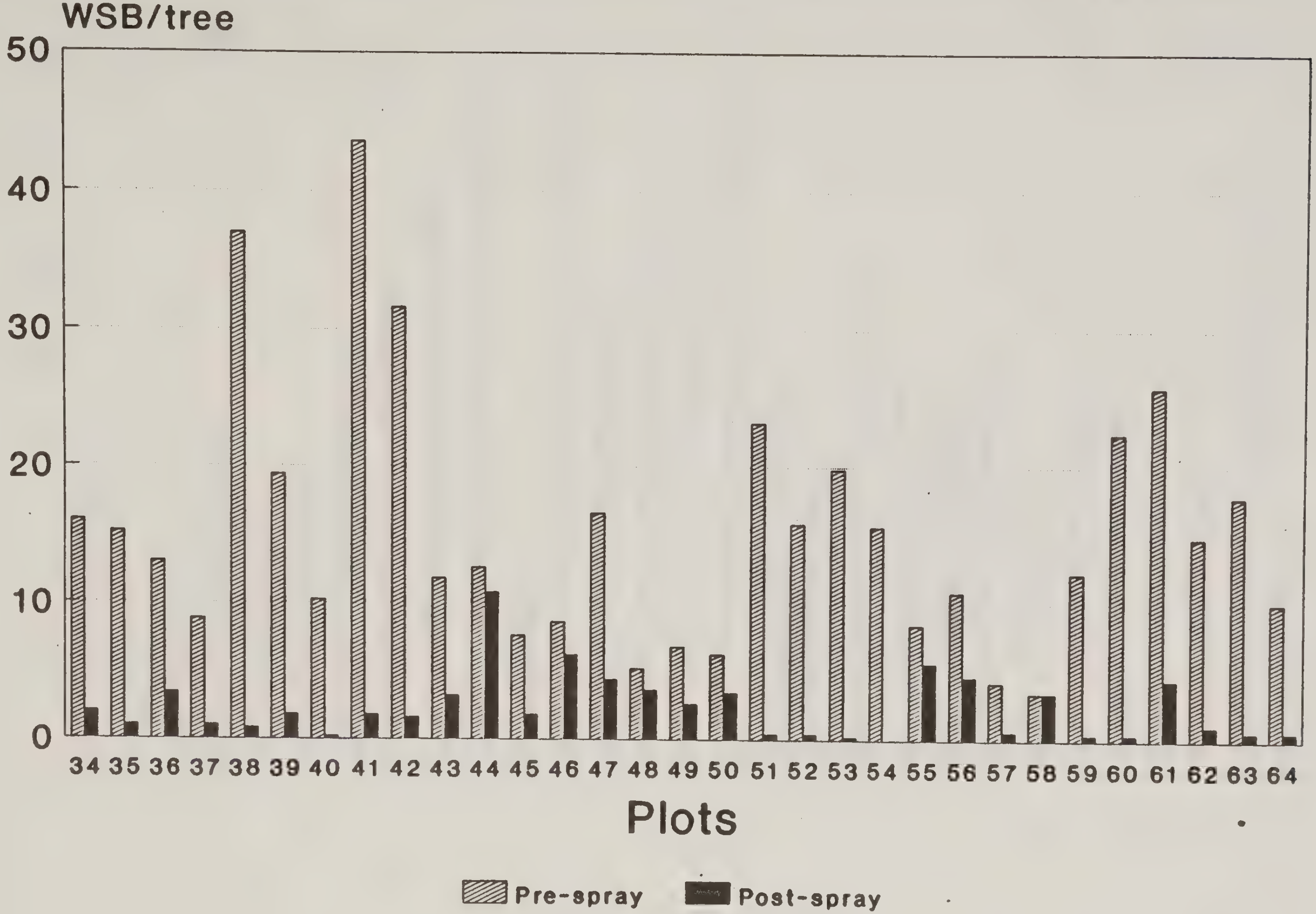


Figure 7. Western spruce budworm plot densities from lower crown branch samples in the Mt. Emily analysis unit.



[illegible]

Figure 8. Western spruce budworm plot densities from lower crown branch samples in the Thimbleberry analysis unit.

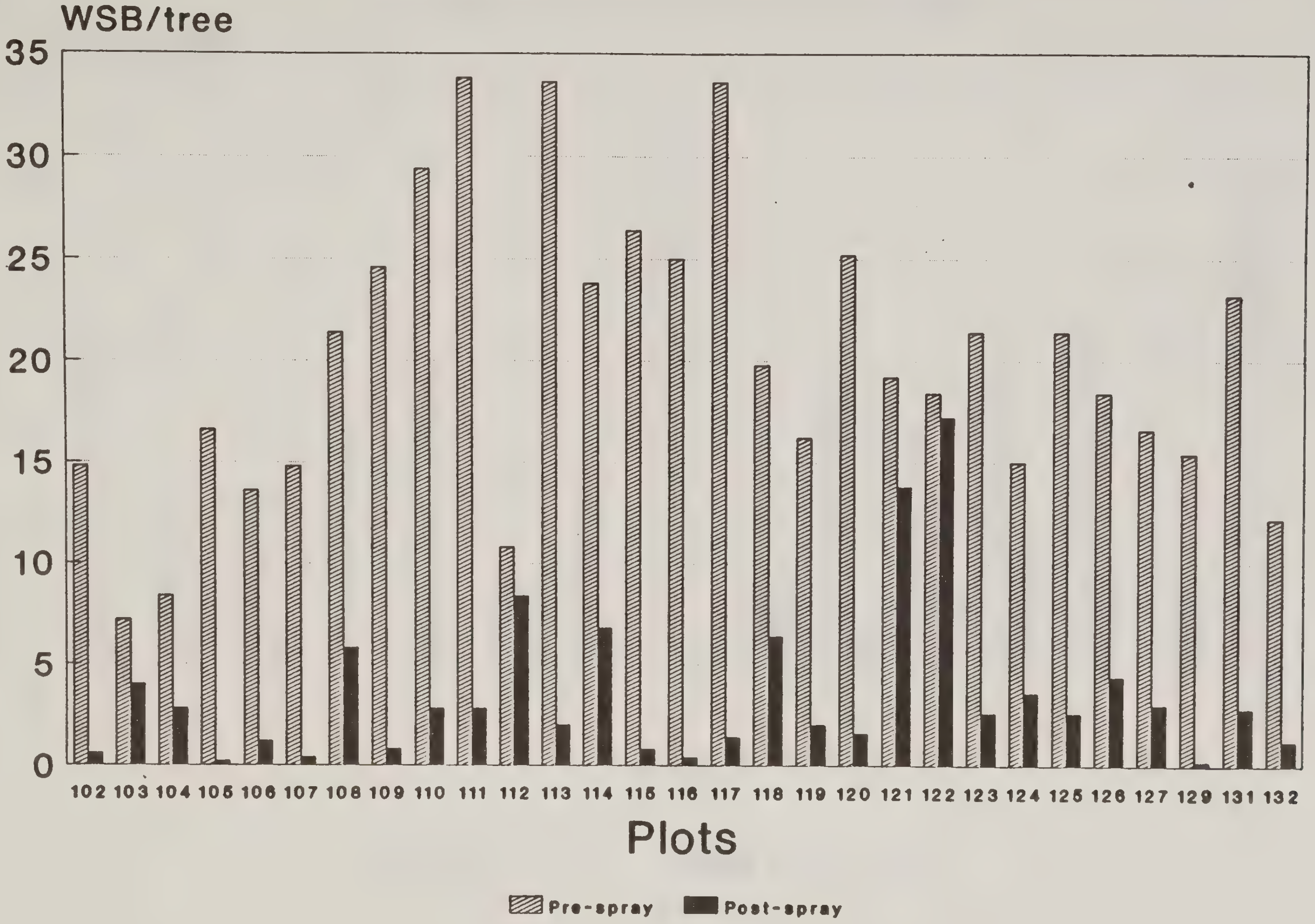


Figure 9. Western spruce budworm plot densities from lower crown branch samples in the Meacham double spray treatment unit.